THE CHEMICAL EFFECTS OF SOLUBLE POTASSIUM SALTS ON SOME ILLINOIS SOILS

BY
LYNNE K. WOOD
A.B., Brigham Young University, 1936
M.S., University of Illinois, 1938

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FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
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I. Introduction

It has been shown in previous work that the status of soil potassium as to availability is a function of the parent material and of the stage and kind of development of the soil; and that in the level prairie lands of Illinois the potassium in the soil decreases progressively from the northeast to the northwest and thence to the south and southeast, following the above principle. The immediate source of potassium supply to the replaceable (available) form is the weathered edges of illite and mica minerals and it has been shown that release of potassium from these unavailable forms is brought about readily by moist storage if the equilibrium that exists between the various forms of soil K is first disturbed by removal of the replaceable potassium. This simulates what occurs in a soil after temporary lowering of the replaceable K level by growth of a crop.

Natural K deficiency in mature soils and that brought about by long continued cropping is due to removal of "weathered edge" potassium faster than it is restored from primary and secondary minerals by weathering. In the present investigation the possibility is studied of conserving and of increasing the "weathered edge" potassium reserve before potassium deficiency for crop growth has become acute, as well as in soils in which serious K deficiency already exists, by reversing the above described release reaction by potassium additions.

II. Methods

Di potassium phosphate in solution was thoroughly mixed with surface soil samples from six University of Illinois experiment fields, ranging from youthful to mature in stage of development. The rates of addition on four fields were 0, 50, 200 and 500 parts potassium per million parts soil. The other two fields received K additions equivalent to 0, 200, 500, 1000, 2000 and 9775 (25 M.E.) parts per million. In

some cases KCl was substituted for the K_2HPO_4. All samples were made into a thin paste, stirred thoroughly, and allowed to dry down to optimum moisture content (19-23 percent) and preserved in sealed mason jars. All treatments and storage were carried out at room temperature. Three forms of soil potassium, namely combined replaceable and water-soluble K (neutral normal NH_4Ac leach), that soluble with a 10-minute extraction in boiling 1.0 normal HNO_3 and that which is insoluble in the latter (by difference) were determined in soil aliquots withdrawn after 8, 16, 25 and 52 weeks moist contact. Net water-soluble potassium was determined on those soils receiving the heaviest additions by leaching with 60 percent methanol. Potassium converted to forms not removed by neutral normal ammonium acetate was considered fixed, and was divided into "acid-soluble" and "acid-insoluble," based on its extractability with boiling 1.0 normal HNO_3. The potassium, after extraction and ignition, was precipitated with sodium cobaltinitrite, dissolved in hexa nitrato ammonium cerate and titrated with sodium oxalate, using nitro orthophenanthroline as indicator.

III. Results and Conclusions

A. Equilibrium.

The results of this investigation indicate that a slowly shifting equilibrium exists between the various forms of soil potassium that may be represented by the following:

I. Primary Mineral K $\rightarrow$ II. Fixed K (a) Acid Insoluble K $\rightleftarrows$ (b) Acid-Soluble K $\rightleftarrows$ III. Replaceable K $\rightleftarrows$ IV. Water Soluble K.

Equilibrium was reached after 16 weeks to one year, depending on the soil used and the amount of K added.

Shifts in the equlibrium apparently occurred by the law of mass action, as increasing additions of soluble K caused increasing shifts to fixed forms.

The native replaceable and acid-soluble K ranged from large to very small amounts in passing from young dark-colored soils to those in late stages of development.

The capacity to fix K in acid-soluble form after additions decreased with increasing stage of development. The gains in acid-insoluble K following additions were more nearly uniform but not consistent.

The more mature soils tended to reach equilibrium more quickly than the young soils. There was also a tendency for fixation to go beyond the equilibrium point, reaching the maximum usually at 16 weeks, followed by a rebound to equilibrium.

Previous fertilizer treatments in the field, including potash applications for many years, had little effect on the reactions involved.

The associated anion exerted a pronounced effect on the water-soluble--replaceable equilibrium and it also affected the ratio of acid-soluble to acid-insoluble K. These relations were greatly modified by the nature of the soil, and the results gave some clues as to the nature of the reactions involved in potassium fixation.

The fact that potassium fixation as it is found in many Illinois soils is an equilibrium reaction is of great importance in the potash economy of these soils.

B. Nature of fixation reaction.

The observed reactions, especially those following very heavy K additions afford some suggestions as to the nature of the reactions involved. The conditions under which fixation was observed in this investigation discount all of the mechanisms proposed in the literature to date. It appears, therefore, at the present stage of this investigation, that Bray's conception of collodial particles having an unweathered core (illite) and weathered edges of beidellite-like properties furnishes conditions which will permit potassium absorption with different degrees of tenacity. This conception, further, calls for a situation in which spaces for the K ions have been provided in the crystal lattice by its previous removal without complete destruction of the lattice itself, thus re-forming an old mineral rather than creating a new one. X-ray patterns of colloids separated from soils containing fixed K were, in general, similar to those from soils not having received K additions. Such a hypothesis accounts for the high fixation in the Cisne silt loam, and the absence of similarly high fixation by the Muscatine silt loam, based on the relative stages of development of the two soils.

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VITA

The author was born March 26, 1915 in Provo, Utah. He received his early education in the public schools of Provo and Standardville, Utah. His secondary education was taken from the Provo and Carbon County High Schools, graduating from Provo High School in May, 1932.

He entered Brigham Young University, Provo, Utah in September 1932 and was graduated from that institution in June 1936. During the year 1936 and 1937 he was employed as a teacher in the Carbon County School District, Utah.

He enrolled in the Graduate School of the University of Illinois in June 1937 and received the degree Master of Science in Agronomy the following spring. He was employed as a part time chemist in the Department of Agronomy from 1937 to 1941 and from 1938 to 1941 held an Assistantship sponsored by the American Potash Institute, Inc.

The author is an active member of Sigma Xi, honorary fraternity in science and Gamma Sigma Delta, honorary fraternity in Agriculture.

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